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PLATE XXVI. Windsor "buds," on Mahaleb. The Mahaleb stocks were treated 7 times in 1891 with Bordeaux mixture and the "buds" were treated 6 times in 1892 with Bordeaux one-third strength. Situation, Row I, near west end.

XXVII. Windsor "buds," on Mahaleb. Similar to those in Plate XXVI, but untreated both in 1891 and 1892. Situation, Row I, near east end, showing defoliation by *Cylindrosporium*.

XXVIII. Early Prolific "buds," on Myrobolan. The Myrobolan stocks were treated 7 times in 1891 with Bordeaux and the "buds" were treated 6 times with Bordeaux one-third strength in 1892. Situation, Row III, west end.

XXIX. Early Prolific "buds," on Marianna. Similar to those in Plate XXVIII, but untreated both in 1891 and 1892. (The difference of stocks upon which budding was done made no difference as regards the leaf-blight; hence the fact that the "buds" in Plate XXVIII were on Myrobolan stocks and in Plate XXIX were on Marianna does not affect the comparison.) Situation, Row IV, east end.

EXPERIMENTS WITH FUNGICIDES IN THE REMOVAL OF LICHENS FROM PEAR TREES.

By M. B. WAITE.

(Plates XXX, XXXI.)

While conducting experiments in the large Bartlett pear orchard near Scotland, Va., on the James River, owned by the Old Dominion Fruit Company, the abundance of lichens on the trees attracted attention. Below are given a few notes on their occurrence, and some observations on the effects of Bordeaux mixture and other fungicides upon them.

Lichens are not ordinarily regarded as injurious to the trees on which they grow. They are epiphytic rather than parasitic, many species living on old fences and rocks, as well as on the bark of trees. Orchardists are more apt to regard them as injurious than botanists, the former generally looking upon them as obnoxious. The fact that various washes have been recommended to be used on fruit trees against the lichens as well as the insects they foster, is some evidence of this. Scraping the bark of the trees has also been recommended for removing these pests.

Lichens seem to attack most severely trees which are not in a vigorous condition. Trees not well fed, and weakened by leaf-blight or other fungous diseases, foster them better than healthy trees and no doubt become still further weakened by their load of lichens. The question of course arises: Is the tree made less thrifty by the lichens or is it infested with lichens because it is not thrifty? At any rate trees badly infested are usually weak trees, inferior to the general average of the orchard, and present a very ragged appearance. The presence of lichens on the trees is certainly not desirable even if not positively objectionable.

It should be noted that the lichens live not only on the rough exfoliating bark of the trunk and larger limbs, but on the smooth growing bark of the smaller branches. In fact the smooth branches seem to have considerably more on them than the old trunks. The fruticose forms are firmly attached to the smooth bark by a small, expanded, disk-like portion of the thallus. The crustaceous forms grow tightly appressed to the bark, or, according to Tuckerman,* the lowest forms grow beneath the outermost layers of the cells of the bark. We see how closely the lichen structure is united to its supporting bark. If not in actual contact it is separated from the green, living bark cells only by an exceedingly thin layer of cork three or four cells deep and not thicker than tissue paper. Furthermore, many species seem to be restricted to the smooth bark. It seems highly probably then that lichens which are in such close connection with the living bark and are more or less restricted to it, take something from the tree. Possibly this consists only of some essential mineral matters, but perhaps also of elaborated sap, and even if they take nothing from the trees their presence may seriously interfere with the functions of the bark.

The Bartlett pear orchard above mentioned has been planted about seventeen or eighteen years. The trees were headed low, and allowed to grow as low, pyramidal standards. Many of the trees had their branches completely fringed with lichens (see Plate XXX). Where the fruticose and foliaceous forms did not cover the limbs the spaces were filled with the crustaceous species. The fringe-like and foliaceous forms are more conspicuous, but the crustaceous forms are probably more injurious.

I am inclined to think that lichens, when abundant, do considerable injury to the trees, although it is hard to get any positive evidence to bear out this belief. The badly infested trees occur in this orchard in patches of several acres in extent, although almost anywhere on the 200 acres the trees were found carrying more or less of the crustaceous forms, if not the larger growths. The crust-like lichens give to the normally smooth yellow bark a grayish, dappled, or spotted appearance, noticeable from a distance.

EXPERIMENTS WITH BORDEAUX MIXTURE.

A block 10 trees square, containing in all about 80 trees, was severely pruned back, the whole top of each tree being removed, leaving only the body and main limbs. This severe treatment and the washing described below were directed primarily against a twig disease, which will be reported on at another time. The object was to remove the twigs and small branches and then to disinfect the remaining parts of the tree of all fungi, lichens, etc.

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*Synopsis of North American lichens, p. VIII.

At the suggestion of Mr. Galloway, Bordeaux mixture was tried for this purpose, applied with a whitewash brush. This treatment was entirely successful against the lichens. The strength used was double that of the old formula, or 6 pounds of copper sulphate and 4 pounds of lime in 11 gallons of water. The mixture was applied to about two-thirds of the trees March 16. A storm of rain and snow freezing on the trees stopped the work, but the remaining trees were painted three or four days later. In using the mixture we had some little difficulty in wetting the lichens by means of a brush. It was slower painting a tree covered with fringe-like lichens than one with smooth bark. Ten minutes was found to be a rather short time to cover one of these small trees. Probably two minutes would suffice for thoroughly wetting the same trees with a sprayer, although a more dilute mixture would have to be used.

It was evident at the time of making the applications that the mixture was taking effect. A few minutes after being wet with the mixture the lichens assumed a greenish, ochraceous color, quite different from their normal grayish tint. On visiting the place again on April 8 examination showed that the lichens were all dead. The fruticose and foliaceous forms were drooping and shriveled, while all were colored a yellowish or brownish tint (see Plate XXXI). During the spring further opportunities occurred for observing the effect of Bordeaux mixture on lichens, while spraying trees in the same orchard for leaf-blight and other fungous diseases. For this purpose the diluted formula (6 pounds of copper sulphate and 4 pounds of lime in 50 gallons of water) was used. Although no special effort was made to spray lichens with the mixture, it was found that whenever thoroughly wet with it they were killed. The weak Bordeaux turned them yellow in the same way as did the strong mixture painted on the trees. On the foliaceous forms, whenever a few tiny drops of the spray struck, the yellow spots resulting were plainly visible. Probably the best way would be to use the regular old formula for Bordeaux and apply it with a sprayer when any considerable number of trees are to be treated, unless it should be demonstrated that the more dilute Bordeaux is equally effective.

EXPERIMENTS WITH OTHER FUNGICIDES.

The satisfactory results with Bordeaux mixture led to the belief that eau celeste might be still more effective. This fungicide is more corrosive to the leaves of higher plants, and is in solution, so that it can be absorbed by a lichen. It was also thought desirable to test different strengths. For this purpose eau celeste was made up according to the original formula, and dilutions made of part of this by adding 2, 3, and 5 parts of water to 1 part of the mixture. Each strength of the fungicide was sprayed upon the lichen-covered trunks of 3 trees until the lichens were wet. A branch of foliage on each tree was also sprayed fo comparison. At that date the petals of the pear trees were falling and the young leaves just expanding.

One week after the application notes were taken as to the effect. On each tree foliage on the sprayed branch was injured, even where the mixture was diluted 5 to 1. The injury consisted of small brown specks occurring over the leaves and larger brown spots around the margins where the liquid had collected in drops. Besides this there was a general yellow appearance and arrested growth. The one-sixth strength did very nearly as much damage as the full strength. The lichens seemed to be harmed but little. The foliaceous forms were discolored somewhat and were injured the most. They were turned slightly reddish or purplish. The fruticose forms were not visibly changed. As with the foliage, the results from using different strengths of the solution varied but little. The full strength was scarcely more effective than the one-sixth dilution. The strong solution turned the foliaceous forms a little redder and scorched the leaves a little more, the difference being only in degree. An examination of the trees in July showed no decided further change in the sprayed lichens, and altogether the effect of eau celeste was unsatisfactory and indefinite. The injury to the foliage would make no difference because the treatment could be made in winter.

At the time the experiments with eau celeste were carried on, a trial was made with chloride of lime, 1 per cent solution, and bichloride of mercury, one-tenth of 1 per cent solution. Both of these solutions caused the foliage to become of a sickly yellow color, but had scarcely any effect on the lichens. They were turned a little yellow in a few places where the solution settled in drops, but the majority looked all right.

CHEMICAL ACTION OF BORDEAUX MIXTURE ON LICHENS.

Bordeaux mixture seems to have some chemical action on the lichen substance. When a drop of it falls upon a dry lichen there is at first no visible action. In the course of a minute or two the drop, which consists of a clear liquid with the blue, flocculent copper compound suspended in it, begins to turn yellowish, and the lichen beneath it takes on the same color. That the color of the liquid was real and not due to the lichen beneath it was proved by removing a colored drop with a small glass tube, in which it still retained its yellow color. The drop gradually becomes yellow and in course of ten or fifteen minutes will disappear, partly by evaporation and partly by being absorbed by the lichen. The result is a greenish yellow spot, with a few blue grains of the copper compound on the surface. It may be that there is some substance in lichens that acts on the blue precipitate of the Bordeaux and dissolves a portion of it, otherwise how could an insoluble compound penetrate a lichen thallus and destroy it? The clear liquid separated from the blue precipitate had no such effect, nor did the lime alone without the copper, as a trial demonstrated. There seems to be some mutual reaction between the Bordeaux and the lichen substance, probably the fungous part, since a test with unicellular algæ gave no such results. This point is worthy of further investigation, and is of interest on account of the possibility of its throwing light on the general question of the action on fungi of the copper compound in Bordeaux mixture and in other insoluble copper preparations. Microscopical examination of a small portion of a lichen thallus which had been treated with Bordeaux mixture and had turned yellowish and dried, showed no marked changes. The chlorophyll, however, had turned a brighter yellow color, and to this is probably due the general change of color.

SUMMARY.

(1) Bordeaux mixture is an effective remedy for lichens on pear trees.

(2) Eau celeste, chloride of lime, (1 per cent solution) and bichloride of mercury, (one-tenth of 1 per cent solution) proved unsatisfactory.

(3) There seems to be a reaction between the lichens and the Bordeaux mixture in which the flocculent precipitate constituting the active principle of the latter is probably partially dissolved and absorbed. As a result the lichens assume a yellow color and die.

DESCRIPTION OF PLATES.

Plate XXX. A Bartlett pear tree near Scotland, Va., infested with lichens. From a photograph taken October 19, 1892.

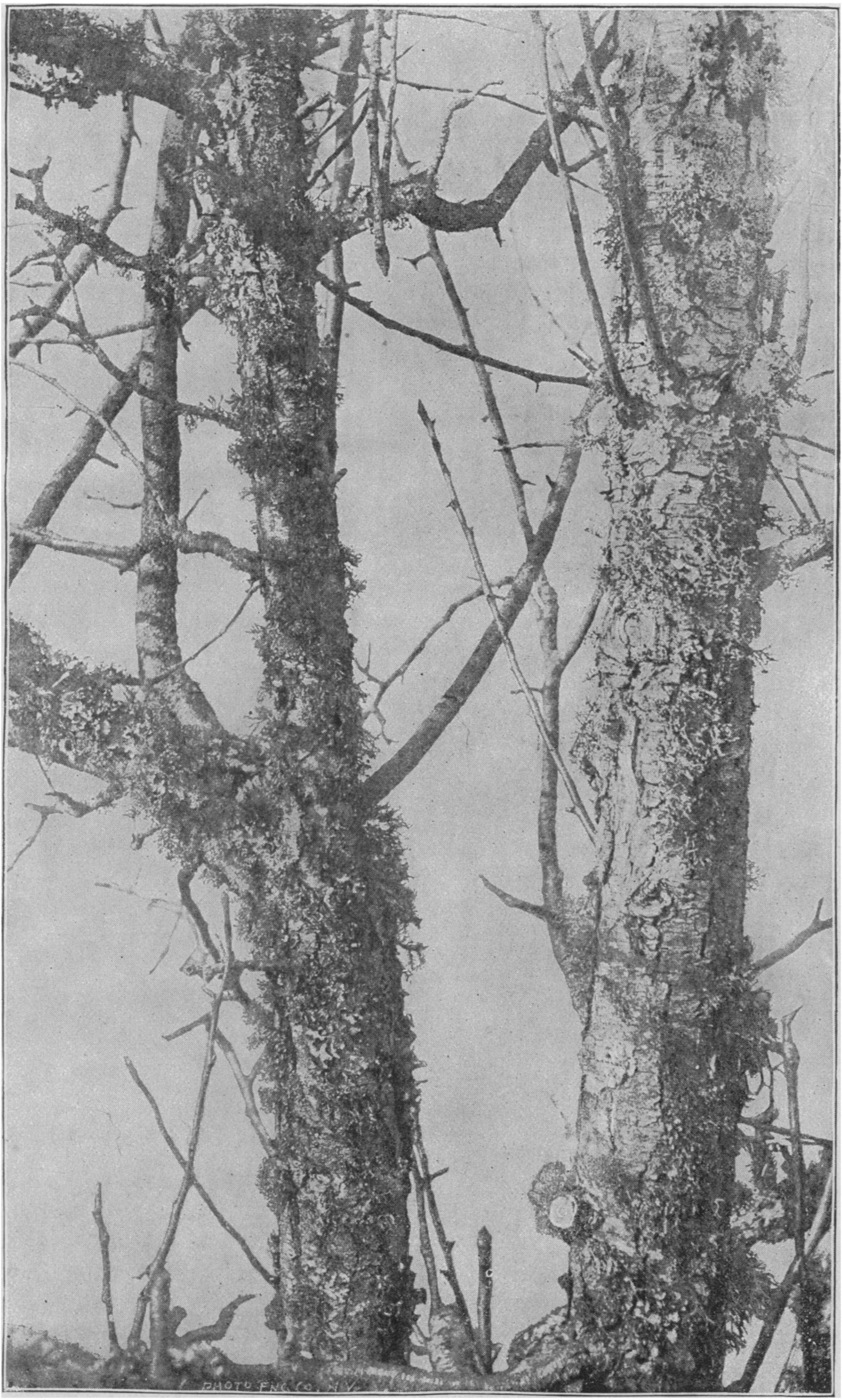
XXXI. Bartlett pear tree in the same orchard which had been treated with Bordeaux mixture, showing the dead and shriveled remains of the lichens. From a photograph taken October 19, 1892.

NOTES ON FOSSIL FUNGI.

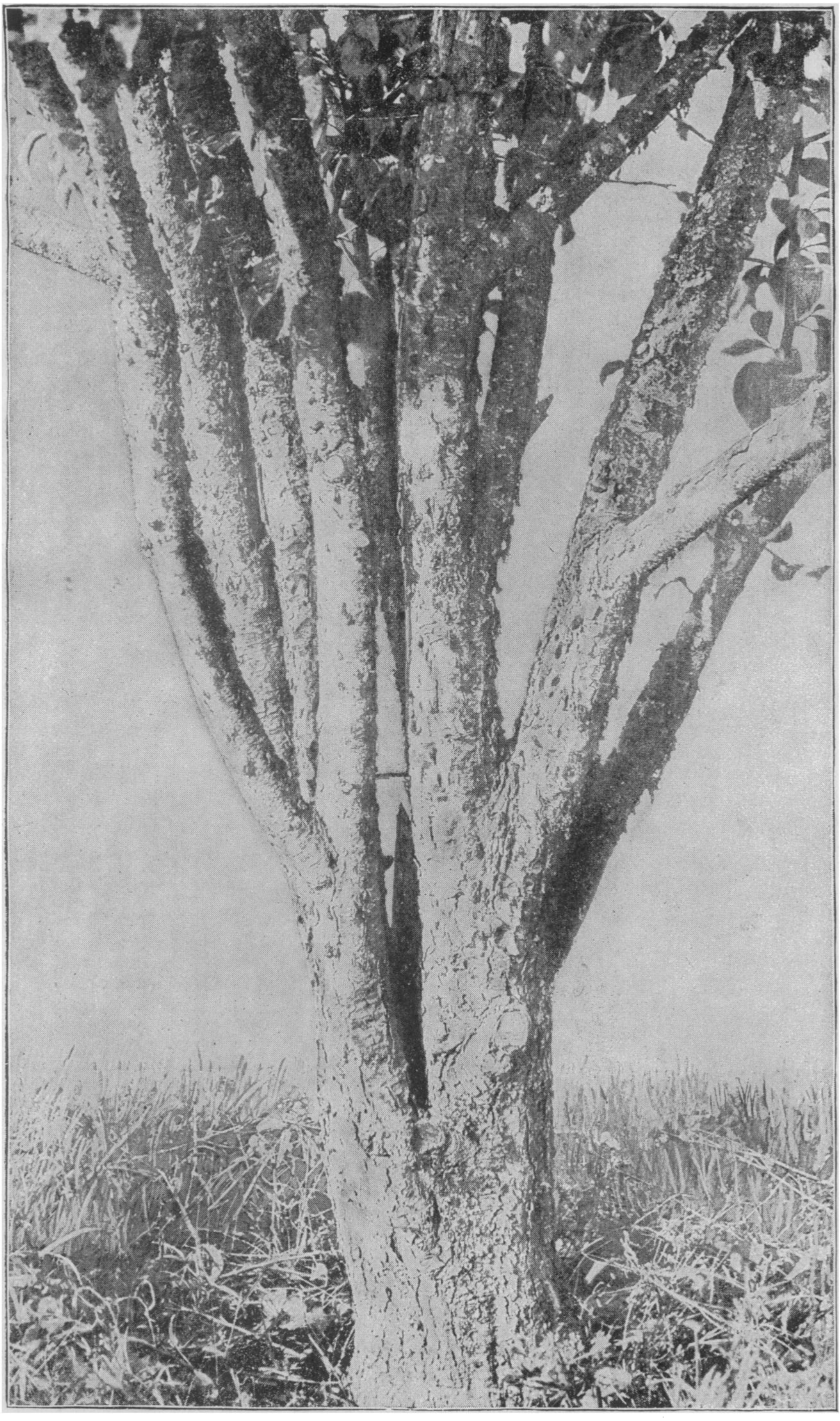
By Joseph F. James.

The enormous number of species and individuals of living fungi presupposes their existence in the past. But their evanescent nature and their peculiar structure render their occurrence in a fossil state comparatively rare. There is great difficulty in keeping many of them with all the care and experience of botanists, and it is natural to expect the vicissitudes of time will operate against rather than in favor of their preservation. During those periods of geological time when vegetation was mainly confined to the sea, we can scarcely expect to find fungi, so that not until the Devonian epoch need we look for evidences of their presence. The Carboniferous period, however, with its

Journal of Mycology, U. S. Department of Agriculture. Vol. VII, Plate XXX.



Branches of Bartlett Pear Tree Untreated and Covered with Lichens. (Waite.)



BARTLETT PEAR TREE AFFECTED WITH LICHENS AFTER TREATMENT WITH BORDEAUX MIXTURE. (WAITE.)